# THERMOSTATIC CONTROL OF FANS IN A REFRIGERATOR CAR OF TOMATOES

(A Preliminary Study)



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## SUMMARY

Thermostatic control of fans in a refrigerator car of tomatoes resulted in slower cooling of the load and less even distribution of temperature than occurred in a conventionally operated (check) car. However, such differences were of minor importance compared to the possibility of avoiding chilling the tomatoes in transit.

Excessive cooling in the bottom layer of the load by convection from the ice bunkers was prevented in one car by installing louvers at the top bulkhead opening to stop natural circulation of air when the fans were not operating. The louvers were effective in stopping cooling by convection even when the bunkers contained an excess of ice.

Without louvers, convection caused undesirable cooling in the bottom layer of the load during train stops and whenever the fans were inactivated by the thermostat. The continued cooling of the load as long as ice remained in the bunkers shows the necessity of limiting the ice supply in cars not equipped with louvers if chilling in transit is to be avoided.

The performance of Car C with only one fan in each end operating most of the time indicates the possibility of improving transit temperatures in tomato cars not equipped with thermostats or louvers by reducing the amount of air circulation.

The thermostats used in this test were more sensitive than necessary and turned the fans off and on too frequently. A smaller thermostat of moderate sensitivity that could be completely buried in a crate of fruit would be more desirable.

## BACKGROUND

The desirability of holding transit temperatures at intermediate levels for certain fruits and vegetables shipped in refrigerator cars has been recognized for some time. Temperatures obtained by normal icing procedure may

cause chilling injury to cold-sensitive commodities such as avocados, bananas, bell peppers, cucumbers, lemons, new potatoes, and tomatoes.

Transit temperatures have been moderated experimentally in fan cars by altering the bulkheads so that some of the air bypasses the ice bunker. Temperatures suitable for tomatoes also have been obtained in fan and nonfan cars shipped with all ventilators closed by limiting the ice supply to a quantity estimated to cool the load to the desired temperature. However, since cars are not all equally well insulated and since outside temperatures during the transit period cannot be accurately predicted, this method of icing the cars does not always give the desired transit temperature. A method of obtaining intermediate temperatures in refrigerator cars without limiting the ice supply is desirable.

The purpose of this test was to determine the effectiveness of thermostatic control of fan operation in maintaining intermediate transit temperatures in tomato cars equipped with electric fans.1/ Stopping the fans at the desired temperature might not in itself prevent further cooling of the load, especially the bottom layer, because of convection of cold air from the bunkers. To prevent convection cooling, one car equipped with self-closing louvers placed over the top bulkhead openings was compared with one not equipped with louvers. In another car the center fan in each bunker was operated normally, while the four remaining fans located near the corners of the car were operated thermostatically. This arrangement provided normal forced circulation of air at a reduced rate when the corner fans were inactivated by the thermostat. A fourth car was operated normally without thermostatic control or louvers.

The cars shipped from Edison, Calif., October 21, 1954, were accompanied by observers to Argentine, Kans., where they were diverted to various markets.

Results show the possibility of maintaining moderate temperatures in refrigerator cars, without reducing the ice supply, by using thermostats to control the fans and louvers to close the top bulkhead openings when the fans are not operating.

## PROCEDURE

### Test Cars

Four Santa Fe refrigerator cars of comparable condition were used for this test. They contained 4 inches of insulation in sidewalls and ends and 4 1/2 inches in the floor and ceiling. Standard equipment included half-stage icing racks, and electric fans. The fans, 12 inches in diameter, were mounted in sets

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1/ The electric relays to control fan operation and the auxiliary louvers to control air circulation in these cars were developed by one of the authors, A. A. McKillop.

of 3 in the top bulkhead opening in each end of the car. Power for the fans was supplied by axle-driven electric alternators when the cars were in motion.

Three of the cars were equipped for thermostatic control of the fans. One of these cars was also equipped with auxiliary louvers mounted over the fans to control air circulation. The louvers were held open by the air blast and were counterbalanced to close whenever the fans were off. Figure 1 shows a panel board containing a set of louvers installed in a car. Thermostatic control was obtained with a Fenwal thermostat (Series 17700) connected by long flexible leads to an Allen-Bradley relay set in the fan circuit. The relay was rewound for 350 turns to withstand the varying voltage and varying frequency produced by the alternator. The relay was activated at a train speed of 10 m.p.h. yet did not overheat at the top speeds encountered. The thermostats with a differential of $\pm$ 0.1° F., proved to be more sensitive than necessary.

Car A (SFRD 3052) was equipped with louvers and had thermostatic control on all fans.

Car B (SFRD 3042) contained no louvers but had thermostatic control on all fans.

Car C (SFRD 3140) with no louvers, had thermostatic control on the 4 corner fans, allowing normal operation of the center fan at each bunker.

Car D (SFRD 3043) had no thermostat or louvers and the fans operated normally at all times.

## Test Equipment

During loading, distant reading electric resistance thermometers were inserted in bottom, middle, and top layer crates of tomatoes along the center line of the load in the 1st, 3d, 5th, and 8th stacks from the bunker in the rear end of the car. One recording thermometer was placed in the middle layer crate in the 2d stack from the bunker. A second recording thermometer was suspended in the air near the ceiling over the 5th stack of crates.

The sensing element of the thermostat was inserted among the tomatoes in a top layer crate near the doorway (8th stack) with the large metal top of the instrument exposed to the air over the load. The thermostats were initially set at 59° F. but were lowered to 50° at Winslow when it became apparent that they were being activated by the ambient air temperature instead of the temperature of the tomatoes.

A multiple-pole operation recorder was used to record the on and off cycles of the fans in the cars with thermostats.

## Loads

The loads contained Pearson tomatoes bulk-packed in 399 wirebound crates of 60-lb. capacity. The crates were placed lengthwise of the car in 7 rows 3 layers high, and 19 stacks long, making solid rows from end to end without center

bracing. The bottom and top layers of crates were loaded tightly against one wall of the car and the middle layer was loaded against the opposite wall, making an offset load which blocked all vertical channels between rows. Railway billing weights of the loads were approximately 26,000 pounds per car.

## Icing

All cars were loaded at Edison, Calif., with bunkers dry. They were switched to Bakersfield and were initially iced on the following day with 3,000 pounds in each bunker on the half-stage racks. The quantity of ice was in accord with the icing schedule recommended for tomatoes in the report "Transit and Ripening Studies with California Mature-Green Tomatoes, Fall 1953." 2/ The cars were forwarded with all ventilators closed from Edison to destination. Car A was re-iced at Belen, N. Mex., with 1,500 pounds in each bunker to test the effectiveness of the louvers in regulating cooling when there was an excess of ice. Cars B, C, and D were not re-iced in transit.

## Routing and Destinations

All cars were routed Santa Fe from Edison, Calif., to Argentine, Kans., where they were diverted as follows:

Car A--to Nashville, Tenn., via Missouri Pacific and Louisville and Nashville railroads.

Car B--to Atlanta, Ga., via Frisco, Central of Georgia, and Atlanta and West Point railroads.

Car C--to Roanoke, Va., via Wabash, Baltimore and Ohio, and Norfolk and Western railroads.

Car D--to Indianapolis, Ind., via Wabash and New York Central railroads.

## Test Data

Records of temperatures in transit, the running time of the train, and estimated fan operation between Edison and Argentine were obtained by the test party accompanying the cars. Data obtained at destination were taken by test personnel who met the cars and inspected them in cooperation with the receivers.

Outside temperatures between Edison, Calif., and Argentine, Kans., were obtained with a recording thermometer attached to the test train. The outside air temperatures along the various routes east of Argentine were approximated from Weather Bureau maps.

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2/ Barger, W. R., Radspinner, W. A., and Morris, Leonard L., "Transit and Ripening Studies with California Mature-Green Tomatoes, Fall 1953." U. S. Dept. Agr., Agr. Mktg. Serv., H.T.&S. Rept. 317, 22 pp., illus. July 1954.

## RESULTS

### Cooling in Transit

The average temperature of the tomatoes in several layers and stacks of the loads at various points in transit are shown in tables 1 to 4. The relation of thermostat setting and ice supply to the cooling of the loads in transit appears in figures 2 to 5.

The tomatoes cooled slightly slower in thermostatically controlled cars A, B, and C than in conventional car D. Also the spread in temperature through the load was somewhat more with thermostatic control but these differences were too small to be objectionable.

Probably because the condition and insulation of the test cars were better than average, the initial icing of 1 1/2 tons in each bunker resulted in more refrigeration than necessary for these tomatoes which were loaded at about 70°F. The temperature of the tomatoes was above the chilling range in all cars but was too low to promote much ripening in transit.

The temperature of the air above the load ranged from 55° and 60°F. between Bakersfield and Winslow in louver car A with a thermostat setting of 59° compared to 45° and 50° in car D with no control. During this time the air above the load dropped to 48° in car B with thermostatic control on all fans but with no louvers and to 45° in car C with control on corner fans only.

The air above the load remained at 50°F. or warmer in louver car A with the thermostat set at 50° after the bunkers were re-iced at Belen.

### Fan Operation

The standing and running time of the train between railway division points from Bakersfield, Calif., to Argentine, Kans., and the estimated time the car fans were in operation are shown in table 5.

The elapsed time from departure from Bakersfield to arrival at Argentine was 70 hours 4 minutes, during which the train was standing 27 percent of the time at stops and delay points and running 73 percent of the time. Fans not controlled by thermostat were in operation during the entire time the train was moving. A comparison of the time the fans were operating in cars A, B, and C with that in car D shows considerable reduction in fan operation owing to thermostatic control (table 5). Apparently the thermostats were influenced somewhat by the cold air above the load since they kept the fans off most of the time between Bakersfield and Winslow when the average temperature of the top layer boxes was above the thermostat setting.

### Louvers vs. No Louvers

The action of the louvers in stopping the convection of cold air from the ice bunkers during off cycles of the fans is shown by comparing the cooling in the bottom layers of the loads in cars A and B, figures 2 and 3. Between Bakersfield and Winslow with the thermostats set at 59°F. and the fans in

both cars off most of the time, the bottom layer cooled much slower in car A equipped with louvers than in car B without louvers. From Winslow to Waynoka, with the thermostats set at 50° and the fans still off most of the time in car A, the bottom layer in this car remained above 55° even after the bunkers were re-iced at Belen, while in car B -- not re-iced, and with longer fan operation -- the bottom layer cooled to 50°. During this part of the trip, the fans remained on in car B despite the cooling of the top layer to points slightly below the thermostat setting, table 5. From Waynoka to Emporia, with 2,000 to 3,000 pounds of ice remaining in the bunkers of car A and with the thermostat set at 59° to keep the fans off, the louvers prevented further cooling of the bottom layer despite the surplus ice supply. The louvers probably prevented excessive cooling in the bottom layer of the load in car A between Argentine and Nashville since the rear bunker contained approximately 1,200 pounds of ice at Argentine.

## Thermostatic Control of Corner Fans Only

The center fans in car C provided continuous but reduced circulation of air after the corner fans were turned off thermostatically. This arrangement prevented excessive cooling of the bottom layer of the load between Bakersfield and Winslow at a time when the corner fans were mostly off, figure 4.

## Ice Meltage

The initial ice supply of 6,000 pounds per car lasted 2 to 3 days. Since the average temperatures of the loads were about the same at Bakersfield the ice meltage was influenced largely by the operation of the fans in the cars. Between Bakersfield and Winslow ice meltage was estimated at 4,500 pounds in car D with normal fan operation compared to 3,000 pounds in cars A and B with thermostatic control and fans off most of the time. During this time the load cooled 19° in car D and approximately 10° in cars A and B. Ice meltage between Bakersfield and Winslow was about the same in car C with the corner fans on thermostat as in cars A and B. In the three cars that were not re-iced, the initial ice lasted longer in the cars with thermostats, B and C, than in conventional car D.

## Warming in Transit

After the initial ice was melted in cars not re-iced in transit, the load temperatures increased gradually during the rest of the trip, figures 3, 4, and 5. However, except in car D, which ran out of ice near Belen, the loads warmed very little before the cars reached Argentine. In car D the load warmed approximately 5° before arriving at Argentine and 4° during the next 2 days. The load in car C warmed approximately 6° in 3 days after the ice was melted. The thermograph from the load in car B indicated that most of the 13° rise in this car between Argentine and Atlanta occurred during the warm weather encountered just before arrival at Atlanta.

## Condition on Arrival

The inspection of the cars on arrival at the market showed the following conditions:

Car A arrived in Nashville on October 27 with fans on and bunkers dry; the car was opened at 5 a.m., October 28. The load had shifted in the front end

of the car, resulting in 62 broken crates.

Car B arrived in Atlanta on October 28 with fans on and bunkers dry; the car was opened at 8 a.m., October 29. The load was in good order.

Car C arrived in Roanoke on October 28 with fans on and bunkers dry; the car was opened at 6:15 a.m., October 29. The load had shifted 4" in the rear end, resulting in approximately 60 broken crates.

Car D arrived in Indianapolis on October 27 with fans on and bunkers dry; the car was opened at 7 a.m., October 28. The load was in good order.

The condition of the tomatoes is shown in table 6. Although the average transit temperature was about 60°F. in each car the tomatoes were not as ripe as desirable. Only 5 to 17 percent of the tomatoes were ripe enough for prepackaging at time of unloading. Car A, with thermostatic control and louvers, had the most firm-ripe fruit on arrival, and car C, with thermostatic control on the corner fans, had the least green fruit, indicating a fair amount of ripening in both cars. Less ripening occurred in car B, with thermostatic control on all fans but without louvers, and very little ripening occurred in car D, operating without control. The ripening in transit was influenced by the rate of cooling of the loads and the minimum temperatures reached. More ripening occurred in cars A and C, which cooled slowly to average minimum temperatures of 53° and 55°, than in cars B and D, which cooled much faster and to minimums of 49° and 51°.

Table 1.--Tomato temperatures in transit--Car A, equipped with thermostatic control on all fans and with louvers

| Place | Date | Time | Average tomato temperatures ° F. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Load | Layers | | | Stacks | | | |
| | | | | Top | Middle | Bottom | 1 | 3 | 5 | 8 |
| | Oct. | P.s.t. | ° F. | ° F. | ° F. | ° F. | ° F. | ° F. | ° F. | ° F. |
| Edison...... | 21 | 6:00 p.m. | 70.7 | 71.1 | 70.5 | 70.6 | 70.8 | 70.7 | 70.0 | 71.5 |
| Bakersfield. | 22 | 10:30 a.m. | 73.5 | 75.0 | 73.4 | 72.0 | 73.3 | 73.7 | 73.0 | 74.5 |
| Barstow..... | 22 | 11:30 p.m. | 68.4 | 69.1 | 68.7 | 67.5 | 64.2 | 70.7 | 68.5 | 70.5 |
| Needles..... | 23 | 6:00 a.m. | 65.9 | 65.4 | 66.4 | 66.0 | 60.5 | 68.3 | 66.0 | 68.0 |
| | | M.s.t. | | | | | | | | |
| Seligman.... | 23 | 4:00 p.m. | 63.4 | 62.1 | 64.0 | 64.2 | 57.7 | 65.6 | 63.6 | 66.8 |
| Winslow..... | 23 | 9:45 p.m. | 62.8 | 61.0 | 63.7 | 63.7 | 57.0 | 65.0 | 63.2 | 61.7 |
| Belen....... | 24 | 6:30 a.m. | 56.4 | 53.6 | 57.2 | 58.5 | 50.8 | 58.7 | 56.0 | 60.7 |
| Vaughn...... | 24 | 11:15 a.m. | 55.4 | 52.7 | 55.9 | 57.7 | 49.7 | 57.0 | 55.2 | 60.0 |
| Clovis...... | 24 | 3:30 p.m. | 54.9 | 51.9 | 55.5 | 57.4 | 49.2 | 56.3 | 54.5 | 59.7 |
| | | C.s.t. | | | | | | | | |
| Waynoka .... | 25 | 4:30 a.m. | 53.3 | 50.2 | 54.0 | 55.7 | 47.8 | 54.0 | 53.0 | 58.5 |
| Emporia..... | 25 | 1:00 p.m. | 53.9 | 51.5 | 54.7 | 55.6 | 49.5 | 54.5 | 53.3 | 58.3 |
| Argentine... | 25 | 4:45 p.m. | 55.3 | 53.5 | 56.1 | 56.4 | 53.7 | 55.0 | 54.2 | 58.5 |
| Nashville... | 28 | 5:00 a.m. | 56.4 | 58.1 | 57.7 | 53.4 | 56.2 | 56.0 | 56.2 | 57.3 |

Table 2.--Tomato temperatures in transit--Car B, equipped with thermostatic control on all fans, no louvers

| Place | Date | Time | Average tomato temperatures ° F. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Load | Layers | | | Stacks | | | |
| | | | | Top | Middle | Bottom | 1 | 3 | 5 | 8 |
| | Oct. | P.s.t. | ° F. | ° F. | ° F. | ° F. | ° F. | ° F. | ° F. | ° F. |
| Edison...... | 21 | 1:00 p.m. | 65.7 | 66.6 | 65.0 | 65.6 | 65.0 | 65.0 | 63.7 | 69.3 |
| Bakersfield. | 22 | 10:30 a.m. | 67.4 | 68.5 | 67.2 | 66.4 | 67.2 | 67.3 | 66.3 | 69.3 |
| Barstow..... | 22 | 11:30 p.m. | 63.1 | 62.2 | 64.0 | 63.1 | 61.2 | 64.5 | 61.5 | 65.3 |
| Needles..... | 23 | 6:00 a.m. | 61.1 | 61.6 | 62.2 | 59.4 | 58.8 | 62.2 | 60.0 | 63.3 |
| | | M.s.t. | | | | | | | | |
| Seligman.... | 23 | 4:00 p.m. | 58.6 | 60.9 | 60.6 | 54.4 | 56.7 | 59.3 | 57.8 | 60.7 |
| Winslow..... | 23 | 9:45 p.m. | 57.3 | 60.1 | 59.1 | 52.6 | 55.2 | 58.0 | 56.5 | 59.5 |
| Belen....... | 24 | 6:30 a.m. | 53.0 | 52.2 | 54.1 | 52.6 | 53.3 | 52.2 | 51.8 | 54.6 |
| Vaughn...... | 24 | 11:15 a.m. | 51.5 | 50.5 | 52.4 | 51.7 | 51.8 | 50.3 | 50.5 | 53.5 |
| Clovis...... | 24 | 3:30 p.m. | 50.0 | 48.9 | 50.5 | 50.7 | 49.7 | 49.5 | 49.2 | 51.8 |
| | | C.s.t. | | | | | | | | |
| Waynoka..... | 25 | 4:30 a.m. | 48.7 | 47.4 | 49.1 | 49.7 | 47.7 | 48.7 | 48.0 | 50.7 |
| Emporia..... | 25 | 1:00 p.m. | 49.0 | 48.6 | 48.9 | 49.6 | 48.5 | 49.0 | 48.3 | 50.3 |
| Argentine... | 25 | 4:45 p.m. | 50.4 | 50.1 | 50.1 | 51.0 | 50.0 | 50.2 | 50.0 | 51.5 |
| | | E.s.t. | | | | | | | | |
| Atlanta..... | 29 | 8:30 a.m. | 63.3 | 64.6 | 63.0 | 62.4 | 63.3 | 64.3 | 62.2 | 63.5 |

Table 3.--Tomato temperatures in transit--Car C, equipped with thermostatic control on corner fans only, no louvers

| Place | Date | Time | Average tomato temperatures ° F. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Load | Layers | | | Stacks | | | |
| | | | | Top | Middle | Bottom | 1 | 3 | 5 | 8 |
| | Oct. | P.s.t. | ° F. | ° F. | ° F. | ° F. | ° F. | ° F. | ° F. | ° F. |
| Edison...... | 21 | 1:00 p.m. | 66.9 | 68.6 | 66.0 | 66.1 | 66.8 | 68.0 | 66.3 | 66.5 |
| Bakersfield. | 22 | 10:30 a.m. | 68.9 | 69.9 | 69.2 | 67.5 | 68.2 | 69.7 | 68.8 | 68.8 |
| Barstow..... | 22 | 11:30 p.m. | 64.5 | 62.6 | 66.9 | 63.9 | 63.3 | 65.6 | 63.5 | 65.3 |
| Needles..... | 23 | 6:00 a.m. | 62.7 | 59.6 | 66.0 | 62.5 | 61.2 | 64.3 | 62.3 | 63.2 |
| | | M.s.t. | | | | | | | | |
| Seligman.... | 23 | 4:00 p.m. | 60.9 | 57.7 | 63.5 | 61.4 | 59.3 | 62.5 | 60.2 | 61.5 |
| Winslow..... | 23 | 9:45 p.m. | 59.2 | 55.6 | 62.0 | 61.1 | 57.8 | 61.3 | 59.0 | 60.0 |
| Belen....... | 24 | 6:30 a.m. | 58.1 | 53.5 | 61.1 | 59.7 | 56.0 | 60.7 | 57.5 | 58.3 |
| Vaughn...... | 24 | 11:15 a.m. | 57.5 | 53.0 | 60.5 | 59.1 | 55.3 | 60.3 | 57.0 | 57.5 |
| Clovis...... | 24 | 3:30 p.m. | 56.9 | 52.5 | 59.6 | 58.1 | 55.0 | 59.8 | 56.3 | 56.7 |
| | | C.s.t. | | | | | | | | |
| Waynoka..... | 25 | 4:30 a.m. | 55.9 | 51.9 | 57.6 | 58.1 | 53.5 | 58.7 | 55.7 | 55.6 |
| Emporia..... | 25 | 1:00 p.m. | 54.6 | 51.1 | 56.0 | 56.6 | 52.7 | 57.3 | 53.7 | 54.7 |
| Argentine... | 25 | 4:45 p.m. | 54.9 | 51.6 | 56.5 | 56.5 | 53.0 | 57.6 | 54.2 | 54.7 |
| | | E.s.t. | | | | | | | | |
| Roanoke..... | 28 | 8:15 p.m. | 59.2 | 58.9 | 59.2 | 59.5 | 58.7 | 59.5 | 59.2 | 59.5 |
| Roanoke..... | 29 | 6:15 a.m. | 60.0 | 59.6 | 60.4 | 60.0 | 59.5 | 60.2 | 60.0 | 60.3 |

Table 4.--Tomato temperatures in transit--Car D, equipped with neither thermostatic control nor louvers (check car)

| Place | Date | Time | Average tomato temperatures ° F. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Load | Layers | | | Stacks | | | |
| | | | | Top | Middle | Bottom | 1 | 3 | 5 | 8 |
| | Oct. | P.s.t. | ° F. | ° F. | ° F. | ° F. | ° F. | ° F. | ° F. | ° F. |
| Edison...... | 21 | 1:00 p.m. | 72.7 | 76.8 | 71.6 | 69.6 | 67.3 | 67.0 | 70.7 | 80.3 |
| Bakersfield. | 22 | 10:30 a.m. | 73.7 | 77.5 | 73.5 | 70.2 | 69.8 | 68.0 | 72.5 | 79.8 |
| Barstow..... | 22 | 11:30 p.m. | 64.6 | 63.4 | 64.9 | 65.4 | 60.7 | 60.8 | 63.2 | 73.5 |
| Needles..... | 23 | 6:00 a.m. | 59.7 | 56.9 | 60.3 | 61.9 | 55.9 | 55.5 | 57.3 | 70.0 |
| | | M.s.t. | | | | | | | | |
| Seligman.... | 23 | 4:00 p.m. | 55.2 | 52.9 | 55.5 | 57.2 | 51.0 | 51.0 | 53.0 | 65.8 |
| Winslow..... | 23 | 9:45 p.m. | 54.3 | 52.1 | 54.7 | 56.1 | 50.7 | 50.2 | 51.5 | 64.3 |
| Belen....... | 24 | 6:30 a.m. | 51.4 | 49.2 | 51.7 | 53.4 | 48.7 | 47.7 | 49.7 | 59.8 |
| Vaughn...... | 24 | 11:15 a.m. | 51.3 | 49.7 | 51.6 | 52.6 | 48.3 | 48.0 | 49.8 | 59.2 |
| Clovis...... | 24 | 3:30 p.m. | 51.7 | 50.9 | 52.0 | 52.1 | 49.2 | 49.0 | 50.7 | 58.0 |
| | | C.s.t. | | | | | | | | |
| Waynoka..... | 25 | 4:30 a.m. | 53.1 | 53.1 | 53.2 | 53.0 | 51.7 | 51.2 | 52.5 | 57.2 |
| Emporia..... | 25 | 1:00 p.m. | 54.8 | 55.2 | 55.0 | 54.2 | 53.7 | 53.5 | 54.8 | 57.3 |
| Argentine... | 25 | 4:45 p.m. | 56.4 | 57.4 | 56.4 | 55.5 | 55.5 | 55.3 | 56.7 | 58.2 |
| Indianapolis | 27 | 3:00 p.m. | 60.5 | 61.3 | 60.5 | 59.8 | 60.0 | 59.8 | 60.7 | 61.5 |

Table 5.--Train running time and estimated operation of car fans in test cars from Bakersfield, Calif., to Argentine, Kans.

| Station | Date | Time | Elapsed time between stations | | | | | | Time car fans were operating | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | | Standing | | Running | | Car A | | Car B | | Car C 1/ | | Car D | |
| | Oct. | | Hr. | Min. | Hr. | Min. | Hr. | Min. | Hr. | Min. | Hr. | Min. | Hr. | Min. | Hr. | Min. |
| | | P.s.t. | | | | | | | | | | | | | | |
| Bakersfield | 22 | 4:30 p.m. | Departure | | | | | | | | | | | | | |
| Barstow | 22 | 11:00 p.m. | 6 | 30 | 1 | 10 | 5 | 20 | 2 | 21 | 2 | 21 | 0 | 25 | 5 | 20 |
| Needles | 23 | 5:45 a.m. | 6 | 45 | 1 | 31 | 5 | 14 | 2 | 35 | 2 | 35 | 0 | 25 | 5 | 14 |
| | | M.s.t. | | | | | | | | | | | | | | |
| Seligman | 23 | 3:45 p.m. | 9 | 00 | 2 | 50 | 6 | 10 | 1 | 22 | 0 | 58 | 0 | 56 | 6 | 10 |
| Winslow | 23 | 9:40 p.m. | 5 | 55 | 0 | 35 | 5 | 20 | 0 | 26 | 1 | 50 | 1 | 41 | 5 | 20 |
| Gallup | 24 | 1:40 a.m. | 4 | 00 | 1 | 00 | 3 | 00 | 2 | 49 | 2 | 53 | 2 | 06 | 3 | 00 |
| Belen | 24 | 6:25 a.m. | 4 | 45 | 1 | 15 | 3 | 30 | 1 | 42 | 2 | 52 | 1 | 22 | 3 | 30 |
| Vaughn | 24 | 11:05 a.m. | 4 | 40 | 1 | 50 | 2 | 50 | 0 | 02 | 2 | 37 | 1 | 45 | 2 | 50 |
| Clovis | 24 | 3:30 p.m. | 4 | 25 | 0 | 50 | 3 | 35 | 0 | 0 | 3 | 19 | 1 | 47 | 3 | 35 |
| Amarillo | 24 | 7:46 p.m. | 4 | 16 | 2 | 26 | 1 | 50 | 0 | 15 | 2 | 22 | 1 | 40 | 1 | 50 |
| | | C.s.t. | | | | | | | | | | | | | | |
| Waynoka | 25 | 4:25 a.m. | 7 | 39 | 2 | 50 | 4 | 49 | 2/ | | 3 | 24 | 1 | 37 | 4 | 49 |
| Emporia | 25 | 12:55 p.m. | 8 | 30 | 2 | 13 | 6 | 17 | 0 | 0 | 6 | 05 | 3 | 46 | 6 | 17 |
| Argentine | 25 | 4:34 p.m. | 3 | 39 | 0 | 45 | 2 | 54 | 0 | 0 | 2 | 43 | 2 | 27 | 2 | 54 |
| Total | | | 70 | 04 | 19 | 15 | 50 | 49 | 11 | 32 | 33 | 59 | 19 | 57 | 50 | 49 |

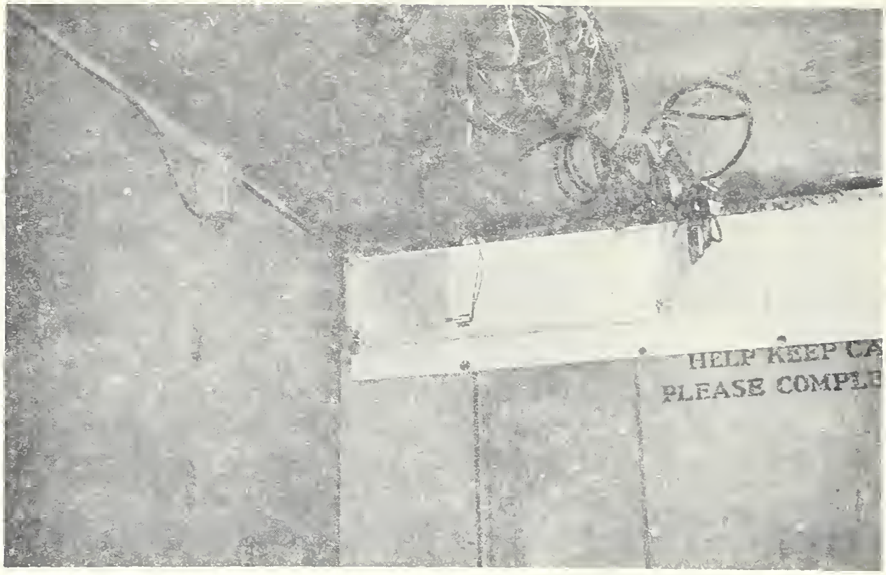
1/ Corner fans only, center fans ran same as those in Car D.

2/ Recorder temporarily disconnected.

Table 6.--Condition of tomatoes upon arrival at the market

| Test car | Average transit temperature | Time in car | Fruits in indicated condition: Green | Turning | Firm ripe | Soft ripe | Decayed |
|---|---|---|---|---|---|---|---|
| | ° F. | Days | Pct. | Pct. | Pct. | Pct. | Pct. |
| A...... | 60.5 | 7 | 66 | 16 | 17 | 0 | (1/) |
| B...... | 58.2 | 8 | 66 | 24 | 9 | 0 | (1/) |
| C...... | 60.0 | 8 | 49 | 45 | 5 | 0 | 1 |
| D...... | 60.8 | 7 | 83 | 11 | 5 | 0 | 1 |

1/ Less than 1 percent.



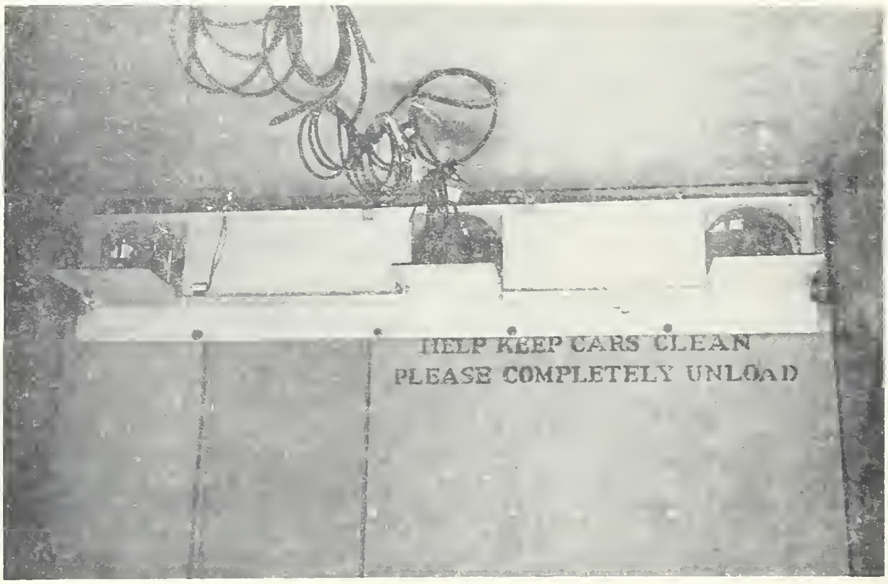




Figure 1.--Counterbalanced louvers mounted over the fan openings in an electric fan car. Upper: In closed position, as during train stops and off cycles of the fans. Lower: In open position, as affected by the air blast from the fans. Other items shown include a relay switch mounted on the left wall of the car, a micro switch mounted on the louver panel at the left and connected with an operation recorder in the business car to record the on and off cycles of the fans, and a set of electric resistance thermometers subsequently used to determine the temperature of the load in transit.

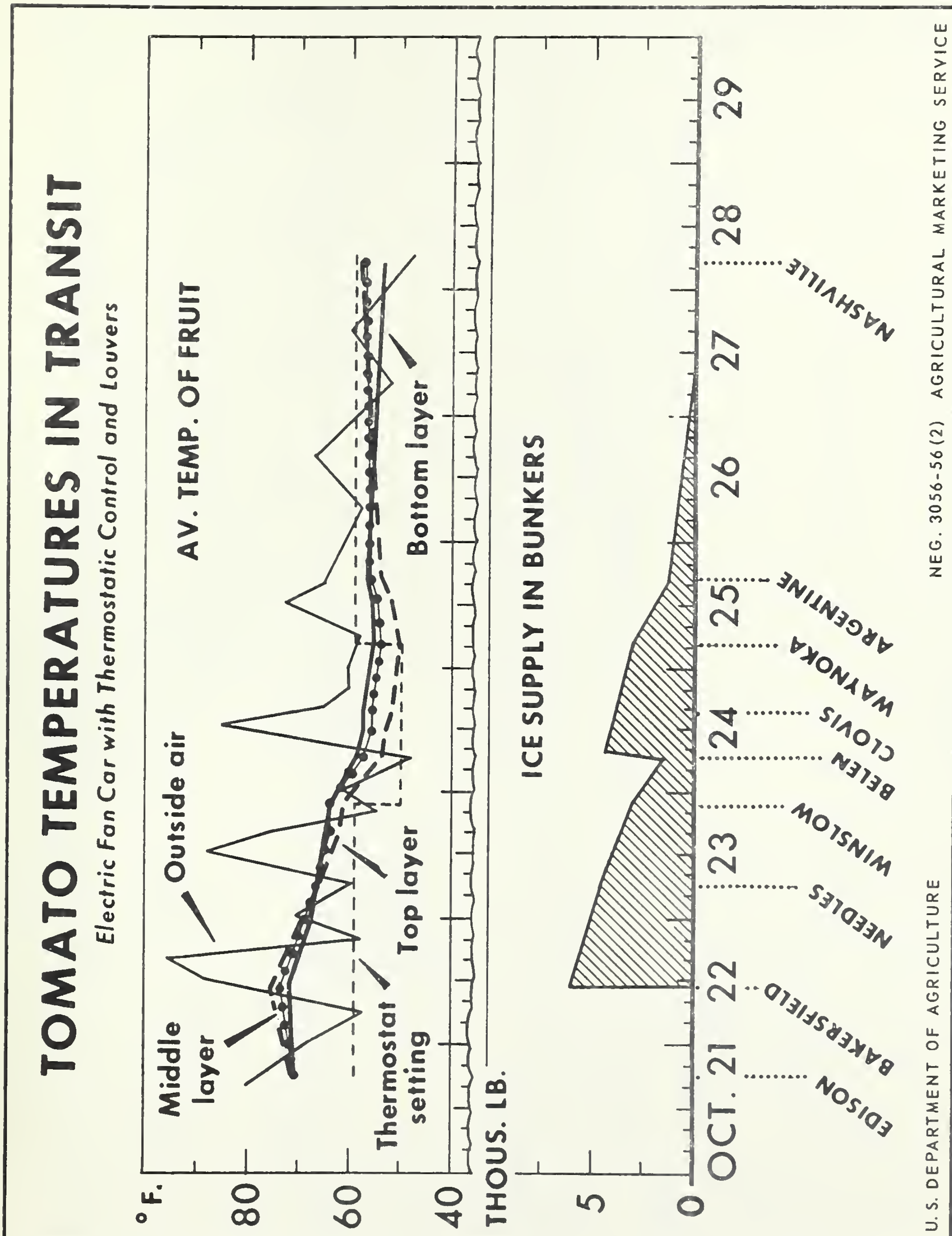

TOMATO TEMPERATURES IN TRANSIT
Electric Fan Car with Thermostatic Control and Louvers
AV. TEMP. OF FRUIT
°F.
80
60
40
Middle layer
Outside air
Thermostat setting
Top layer
Bottom layer
ICE SUPPLY IN BUNKERS
THOUS. LB.
5
0
OCT. 21
22
23
24
25
26
27
28
29
EDISON
BAKERSFIELD
NEEDLES
WINSLOW
BELEN
CLOVIS
WAYNOKA
ARGENTINE
NASHVILLE
U. S. DEPARTMENT OF AGRICULTURE
NEG. 3056-56 (2) AGRICULTURAL MARKETING SERVICE

Figure 2

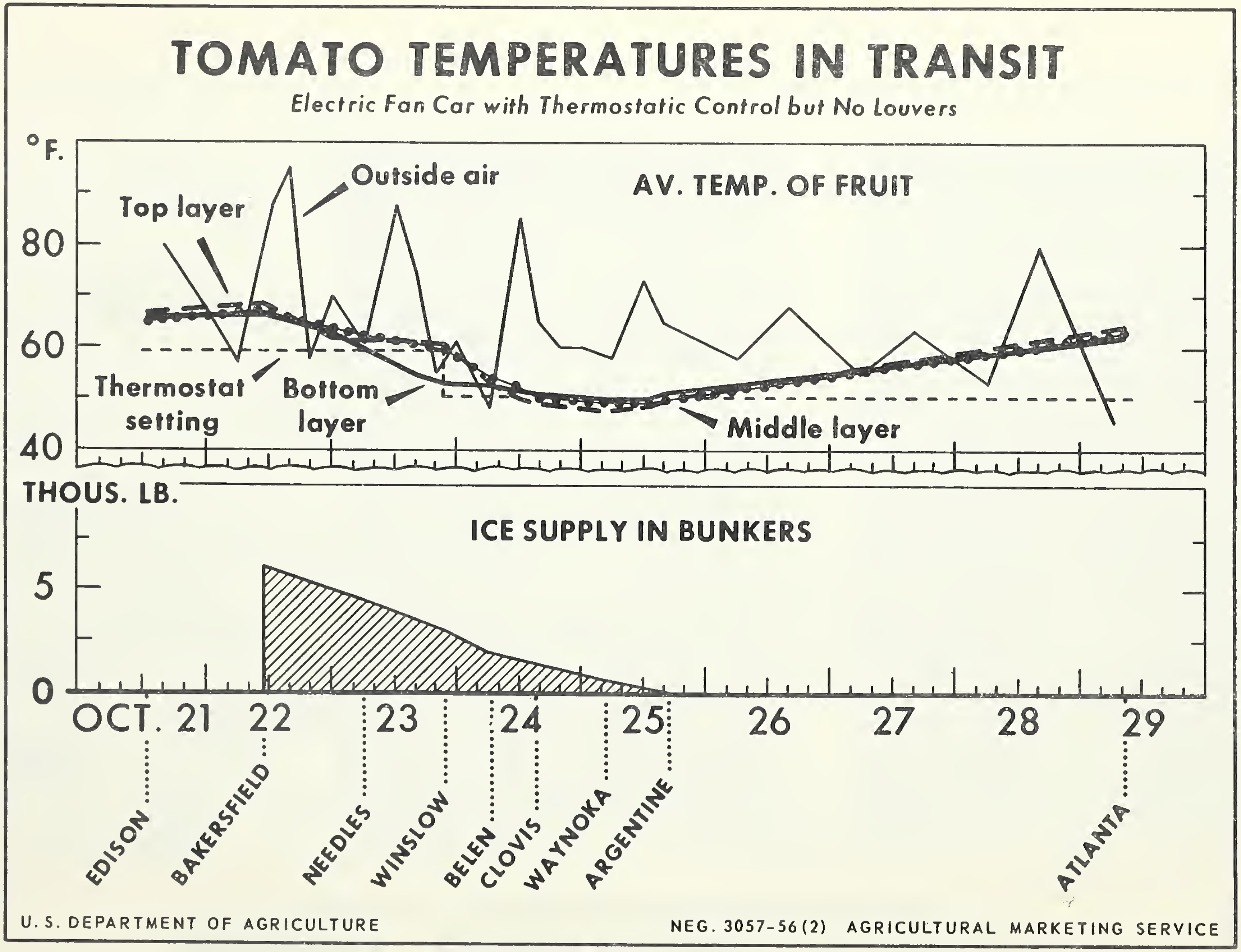

TOMATO TEMPERATURES IN TRANSIT
Electric Fan Car with Thermostatic Control but No Louvers
°F.
80
60
40
AV. TEMP. OF FRUIT
Outside air
Top layer
Thermostat setting
Bottom layer
Middle layer
THOUS. LB.
ICE SUPPLY IN BUNKERS
5
0
OCT. 21
22
23
24
25
26
27
28
29
EDISON
BAKERSFIELD
NEEDLES
WINSLOW
BELEN
CLOVIS
WAYNOKA
ARGENTINE
ATLANTA
U. S. DEPARTMENT OF AGRICULTURE
NEG. 3057-56(2) AGRICULTURAL MARKETING SERVICE

Figure 3

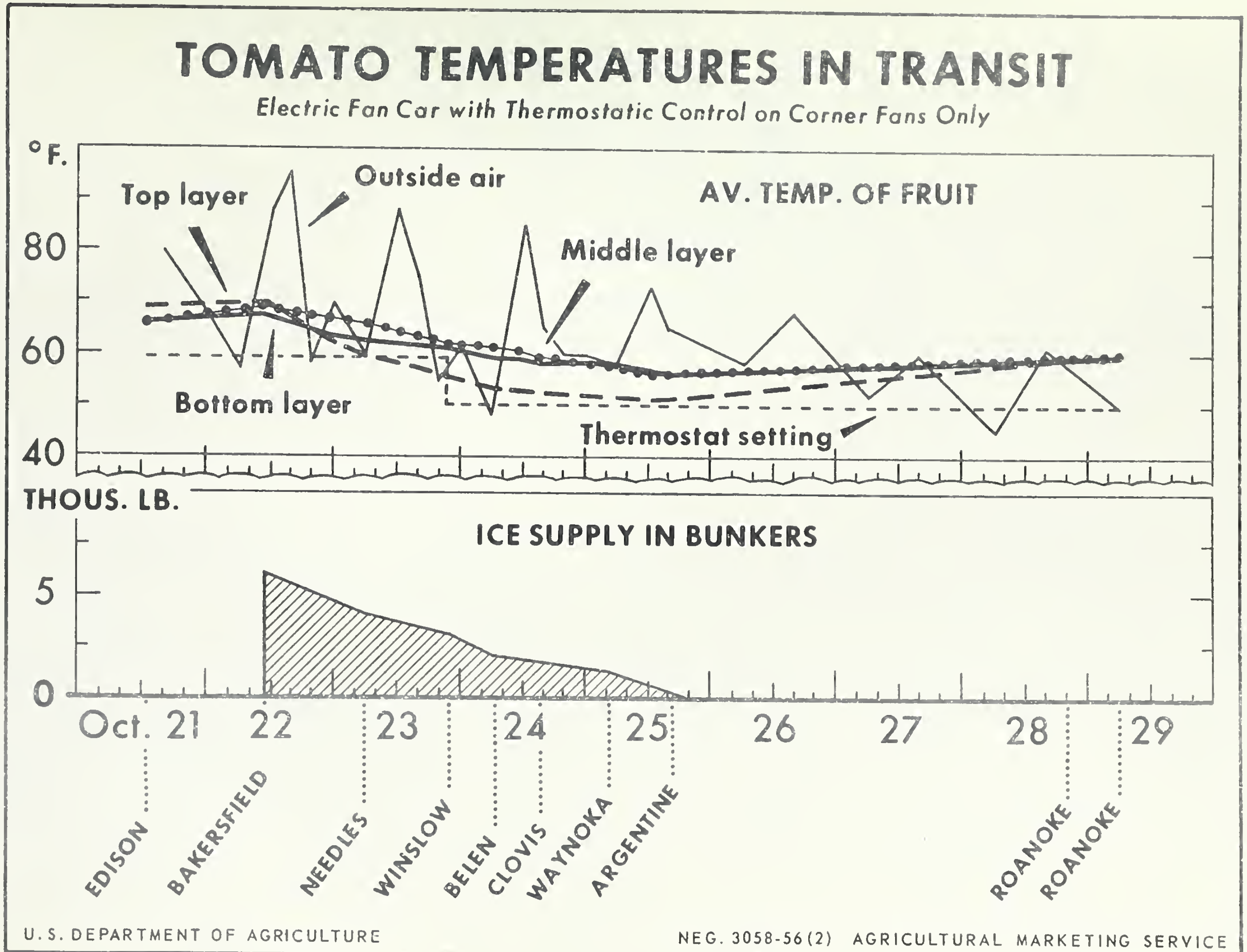

TOMATO TEMPERATURES IN TRANSIT
Electric Fan Car with Thermostatic Control on Corner Fans Only
°F.
80
60
40
Top layer
Outside air
AV. TEMP. OF FRUIT
Middle layer
Bottom layer
Thermostat setting
THOUS. LB.
ICE SUPPLY IN BUNKERS
5
0
Oct. 21
22
23
24
25
26
27
28
29
EDISON
BAKERSFIELD
NEEDLES
WINSLOW
BELEN
CLOVIS
WAYNOKA
ARGENTINE
ROANOKE
ROANOKE
U.S. DEPARTMENT OF AGRICULTURE
NEG. 3058-56(2) AGRICULTURAL MARKETING SERVICE

Figure 4

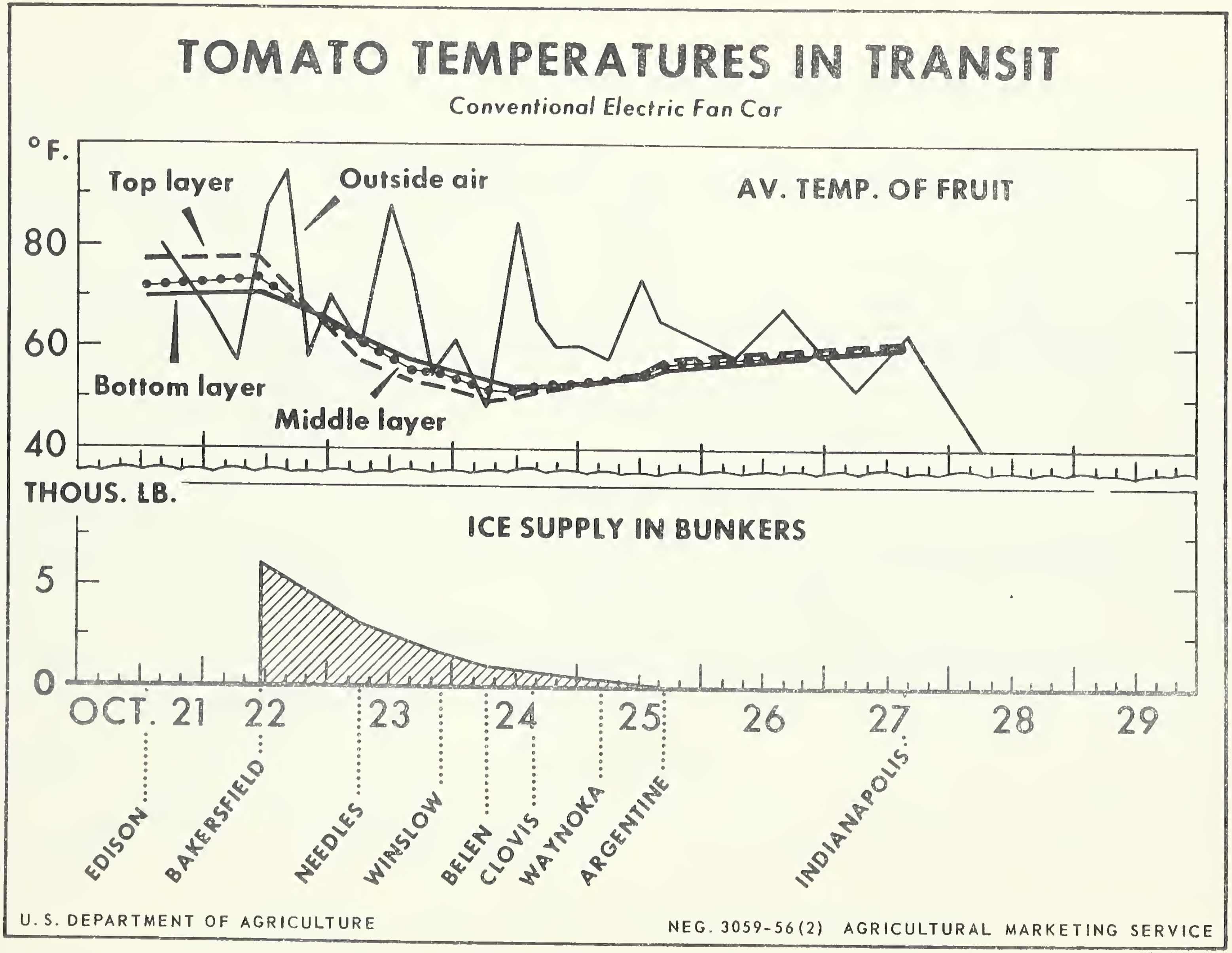

TOMATO TEMPERATURES IN TRANSIT
Conventional Electric Fan Car
°F.
80
60
40
Top layer
Outside air
AV. TEMP. OF FRUIT
Bottom layer
Middle layer
THOUS. LB.
ICE SUPPLY IN BUNKERS
5
0
OCT. 21
22
23
24
25
26
27
28
29
EDISON
BAKERSFIELD
NEEDLES
WINSLOW
BELEN
CLOVIS
WAYNOKA
ARGENTINE
INDIANAPOLIS
U. S. DEPARTMENT OF AGRICULTURE
NEG. 3059-56(2) AGRICULTURAL MARKETING SERVICE

Figure 5